Statistical Control Including Costs as a Factor in Production

By HARLOW S. PERSON
Managing Director, The Taylor Society,[1] New York City

General. A manager desiring to determine the best place at which to locate a particular type of retail store, considers possible locations from many points of view, including casual observations of the places where the greatest number of possible customers seem to pass. He then stations at each of these places an observer who, in a square on a tally-sheet ruled in a carefully predetermined manner, makes a mark as each person passes. After the observations have been completed and the marks in the various squares are counted, the manager is enabled to establish a number of facts pertinent to the problem such as the following: the average number of persons who pass during a day; the average who pass each hour of the day; the average number of men who pass each hour of the day; of women; of children; the number of office girls who pass during the lunch hour; etc. These group facts, discovered by recording and classifying the mass of unit facts, are of importance in helping him to decide a problem of business policy.

If a merchant sells hats for a season and keeps no record of sizes sold, he is at a loss to place precise orders for the next season. He may have a general impression that he had better place in stock more of a given size than of other sizes, but a "general impression" is not precision, control and economy in operation. On the other hand, if he has kept records, he may find he has sold 50 size $6\frac{1}{2}$; 150 size $6\frac{3}{4}$; 300 size 7; 500 size $7\frac{1}{4}$; 400 size $7\frac{1}{2}$; 150 size $7\frac{3}{4}$; etc.—in all some 1600 hats. He estimates that his sales will amount to 2000 hats next season and divides the order for that number in the ratios with respect to size, of .5, 1.5, 3, 5, 4, 1.5, etc., and feels certain that he is forecasting his market with precision.

These illustrations should suggest to the reader the nature, the

[1] A Society to Promote the Science of Management, Engineering Societies Building, 29 W. 39th Street, New York City.

purpose and the methods of statistics in business. An illustration might have been used in which facts are entered on "forms" in an office, as documents resulting from operations and carrying different kinds of data (units of product; wages; sales; complaints; prices of materials; etc.) pass through the office. The magnitude of the business, the volume of the data, the number observed, recorded, classified, compared and otherwise handled, make no difference.

Nature and Purpose of Statistics. A "fact" the relations of which are obscured has little or no significance. A single person passing the observer in the first illustration has no meaning or importance. Related to the problem of locating the store he begins to assume importance. Related to that problem as one person in an aggregate of persons passing the observer, he becomes *in this relationship* of great importance; but by becoming part of an aggregate of persons he is transformed into one of a mass of data so numerous as to confuse the mind, which is limited in its processes of observing, valuing, remembering and comparing separate experiences which come to it casually. The mind is unable to grasp the significance of larger summarizing facts behind or contained in the mass. Yet there are summarizing facts there, facts which result from the bringing together and analysis of the aggregate. Statistics is the science and the art of handling aggregates of facts—observing, enumerating, recording, classifying and otherwise systematically treating them—so that other "master" facts or principles or laws lying behind or contained in the aggregate are made comprehensible to the mind and become, along with the results of other methods of investigation, data for reasoning, the drawing of conclusions, the making of decisions and the determination of policy.

Statistical Methods. There have been developed many devices for the summarizing and analysis of statistical data such as the *per cent* and the *arithmetic average.* No manager of a plant of any size, for instance, could carry in his head the number of hirings and separations for two or three years. Yet if recorded these facts can be classified and summarized through the medium of coefficients, and the mind can easily reason in terms of the coefficients, which sum up group facts behind the unit facts. That labor turnover was 43 per cent in 1918 and 27 per cent in

1919 is the statement of two significant, comprehensible, summarizing facts yielded by proper treatment of a large number of accumulated unit facts, which considered individually had relatively little significance. The business statistician does not need, in the present stage of the development of the art of statistics in business, to go into such refinements of statistical method as are necessary for, let us say, the biologist, or even a department of public health. Extreme refinements of method yield only a fictitious accuracy when the preceding steps of observation, enumeration and classification are lacking in precision, or the data are not in great volume, which is usually the case in a business. The accuracy of a chain of reasoning can be no greater than its weakest link.

But if refinement of method in the mathematical treatment of data is unnecessary in the use of statistics in business, too great care cannot be exercised with respect to the collection of data. The summarized data become premises for reasoning, and to the extent that they have been incorrectly labeled and classified in the process of collection and recording, the reasoning and the conclusions of which they become the basis are unreliable. The skilled statistician wants to know how the data were collected—are they complete or a good sample of the mass of unit facts under consideration; is classification exact; are compared averages the averages of like things; etc.? The critical stage in statistical investigation is the first stage; the determination of the purpose of the investigation; precise definitions of different kinds of unit facts to be recorded; the careful recording, classification and summarizing of these unit facts in accordance with the precise definitions. From that stage on statistical processes are simple. It is in that stage that the difficulties lie and the errors are made.

Homogeneity of Statistical Units. That the original units of observation and record should be homogeneous is the primary rule of all worth-while statistical effort. This depends upon careful definitions. If definitions are not exact, dissimilar things will be enumerated under the same head by different observers or recorders, homogeneity will not exist and the summaries and averages will not be comparable. One recorder might include under "wages" some payments that another includes under "salaries." One might include under "worked materials"

some things that another includes under "stores." One might include in the length of time it takes to perform an operation, the time between the start and finish of the operation that the machine is idle; another might not. The statistics of labor turnover published today are generally incomparable because of this error. In one plant "separations" is made the basis of computation; in another "hirings." In one plant the working force may be increasing, in another decreasing; neither "separations" nor "hirings" has the same significance in the one as in the other. Different unit facts are classified under the same head and the law of homogeneity is violated. Resultant averages are not comparable.

The primary statistical fact—statistical unit—observed and recorded should not be a compound fact. To use a chemical analogy, it should be an element. Compounds can be built up, if desired, by bringing elements together. The recording and analysis of homogeneous primary facts require planning ability and cost money, but they are the only facts worth recording. Later attention will be directed to the use of mechanical devices which make possible the recording and classifying of unit facts at a reasonable cost.

Statistics in Business. The application of statistics was first developed by governments and quasi-public institutions in the study of social phenomena and was then developed and carried to the highest degree of perfection in technical method by the biologists in the study of the laws of heredity. In these fields the data have always been so numerous as to compel statistical treatment, and in these fields great discoveries have been made by the statistical method of investigation. Among business institutions the first to use statistical methods were the insurance companies, railroads and similar businesses, the data of whose operations are voluminous and usable only when statistically handled. With the broadening of markets and the increase in the size and in the volume of business of other industrial institutions, the use of statistics increased as an aid in establishing standards, and in interpreting facts as a basis for the forecasting of tendencies and the determination of policies. Today there are few large business institutions in the United States—manufacturing or distributive—which do not have statistical departments,

and regard for the statistical function in smaller institutions is increasing with great rapidity. There is scarcely a business of any size which could not use statistics to advantage, the size of the "statistical department" being purely a problem in overhead cost to be viewed in the light of probable returns. There is an advertising company which carries an immense and costly statistical overhead, but the result of the work of that department has made the company impregnable in competition; its clients have confidence in its advice. I know of a small distributing house in which a young graduate of a school of business administration, along with other duties and on his own initiative, began to record, classify and analyze data according to the statistical method. In one year he proved "master facts behind the mass of unit facts" never before observed, and influenced purchase policy and sales policy—for the business he effected economies resulting from operations in accordance with better policies, and, for himself, proved himself worthy to be a branch manager. Between these two extremes may be found throughout business a great variety of methods of utilizing statistics in investigation.

The Practical Objects of Statistics in Business. The principal objectives of the use of statistics in business are:

1. To ascertain inner, controlling, master facts which cannot be ascertained by casual observation of the complex mass of obvious facts which constitute the experience of the business and in which they are contained. The sales manager about to undertake a sales campaign, does not trust to chance or to casual observation more than is necessary. He investigates and analyzes characteristics of the consuming public in a market—estimates among other things their probable demand for and capacity to purchase the particular commodity he proposes to introduce, and the kind of advertising methods to which the purchasers of that market are most likely to react. The utility corporation analyzes statistically a growing suburb before it determines its policy of extension and capital investment. The merchandise and credit managers of a wholesale distributing house estimate the purchasing power of a region, through the statistical analysis of crop and other governing conditions, before determining policy with respect to a season's business. The manager of a retail store may analyze sales of different articles by sizes, seasons,

etc., in order to determine a quality, quantity and seasonal schedule of purchases, thereby adjusting orders to probable turnover.

2. To determine standards by which to value and guide *current* performance and in terms of which to estimate *future* performance. The merchandise manager of a department store receives each morning a summary sheet showing sales of the preceding day compared with sales of the same day the year before; cumulative sales of the month to date compared with cumulative sales of the corresponding period of the year before and with estimates for the current month; cumulative sales of the year to date compared with those of the corresponding year before, and so on. He can ascertain at a glance whether sales are going well; if they are not he may institute at once a special sales campaign. Likewise any business selling commodities or services. A production manager time-studies operations under different conditions and with different materials and methods, and by statistical treatment of the data establishes several standards: standards of conditions; of materials; of methods; of performance. He can then value and guide current performance and can estimate with precision future performance. He may keep his record in terms of units of output and in terms of units of cost. Cost units are no different from other units in statistical treatment. A telephone company analyzes statistical records of calls and establishes a standard of performance for an operator or for a system and on the basis of these standards can determine whether an operator is efficient or a system is approaching the volume of business for which it will be inadequate, requiring extension or replacement. The electric light or telephone or other similar company, by statistical records determines the hours, the days and other seasons when its various peak loads are bound to occur, and establishes operating policy accordingly. A supply division of the army or navy, by statistical methods, determines a procurement and delivery schedule for an army of a given size under predetermined conditions of activity, and by similar statistical methods determines from day to day whether the schedule is being observed.

The use of statistics in determining such standards for measuring current performance and estimating future performance

is one of the latest developments of the use of statistics in business, offers one of the most profitable instruments for improvement in managerial methods, and unfortunately involves some of the greatest dangers of misuse. These misuses are prevalent in current practice. The first is the error of so organizing the function of recording, classifying and analyzing data as to secure the returns too late for use in controlling *current* operations, in which case the statistics are but records of past performance and have so limited a usefulness as to raise the question whether they are worth the cost of collection. The second error is that the units of enumeration may not be homogeneous, and to the extent that they are not, their value in the control of current practice or of forecasting future performance is invalidated. A time (statistical unit) of a performance by method A under condition B with material C on machine D is not homogeneous with a time resulting from a study when either A, B, C, or D is different. Three complaints, one resulting from disturbed mail service, one resulting from a defect in the goods, and one resulting from discourtesy of a clerk, are not homogeneous. To record them simply as "complaints" may enable a manager to enjoy the sensation that something is wrong, but will give no precise information which will enable him to control the situation and remedy the causes. The third error in the use of statistics in establishing standards and measuring performance is that the units of statistical record may not correspond to the units of the operating processes. This is a common error, for only too frequently the statistical function is not recognized as a production function, and the statistical department and methods are developed independently of the production department and methods. The analysis of processes by the production manager for the purposes of operating control is different from that of the statistical department for purposes of record, with the result that the statistics fail to be useful to the production manager. The same authority that approves the establishment of production methods should approve the establishment of statistical methods in so far as they are concerned with statistics of operation, in order to insure that the units of statistical record shall be identical with the unit process of production. Furthermore, the only way of assuring such correspondence is to make the "papers" which control

production the original documents from which statistical data are drawn.

3. To establish series of facts which suggest tendencies, or permit comparisons which suggest causal relations, or at least correlation, between series. Time curves may be plotted showing sales—by salesmen, by territories, by articles, etc. By these the sales manager may keep informed concerning the sales tendency in a territory, of a commodity, or of a salesman. Comparison of these curves may permit the manager to determine that the salesman whose record of gain is best is concentrating on leaders which yield small profit while a salesman whose record for gain is not so good may be selling a wider variety of articles, thereby laying the foundation of a better long-run business in his territory. Curves of wages paid, hours of work, output per man, separations, hirings, cases of discipline, idle machine time, etc., may be compared and correlations proved—i. e., it may be observed that when one curve shows a particular tendency another shows a similar or different particular tendency. The establishment of such correlations permits more accurate forecasting of results and the establishment of more dependable policies. There is opportunity for the development of statistics of this kind in every business and the results may be considerable, but in no two businesses is it the same, and each is a field for special study.

There are many data pertaining to the social-industrial conditions in which a business is carried on, of importance to every manager in determining policy, but to collect, classify and analyze these would be too great a burden of cost for one business. We have in mind data relating to crop conditions, prices of basic materials of industry, bank clearings, commercial failures, etc., which when consolidated and compared throw light on general business conditions. Statistics of this sort are now available through statistical service agencies,[2] and it is not necessary for the individual business to secure them. But there remains a considerable number of special "lines" of statistics, especially pertinent to its materials, products and markets, which a business may profitably maintain.

[2] For instance, services rendered by Roger Babson, Inc., and by the economic research bureau associated with the Harvard Graduate School of Business Administration.

4. To determine laws governing industrial operations. A comparison of different lines of statistics might disclose such relations as to prove principles to which the term "law" could properly be applied. Extraordinarily large numbers of homogeneous data are essential to the establishment of laws. These are seldom available in the records of a single industrial concern. The most noteworthy case of the scientifically precise observation, recording, classification, analysis and general statistical treatment of industrial data which has led to the formulation of laws, was the study by Mr. Taylor and his associates which led to the discovery of the laws of metal-cutting, which revolutionized that art. The hope of the discovery of laws governing industrial operations depends upon the pooling of the statistical interests of many concerns—coöperative statistics which will yield homogeneous data in great volume.

Cost Accounting. Cost accounting is a specialized phase of statistics. It is statistics in which the statistical units are monetary values—cents, pence, centimes. The principles of the statistical treatment of these units are no different from the principles of the treatment of other units—pounds, gallons, bushels. Cost statistics are subject to every law governing general statistics, and most of the troubles in cost accounting are the result of disregard of statistical laws. Cost statistics should be derived from operating "papers"; these papers should flow in a constant stream over the desks of cost and other statistical clerks and keep the record "up to the day" as a basis for *immediate control* of operations; the cost unit data should coincide with or dovetail into the unit data of other phases of statistics; they should be homogeneous. Costs which have been derived in accordance with these principles are worth the expense; costs which are but the record of past events—records got up too late to influence current action and in classes which do not correspond to classes of operations in the shop—are seldom worth the expense of collection.

Mechanical Devices. The principal obstacle which is met in the development of the cost and general statistical methods here recommended is the clerical expense involved. The expense of copying data from operating forms on to special statistical department forms, and then of computations and tabulation,

is frequently prohibitive. But it is possible to adapt the cards of the standard sorting and tabulating machines for use as original operation orders, and they become, after their use in operation, the data cards of the cost and other statistical clerks. One firm at least[3] has economically secured extraordinary results in this way. The economy resulting from the use of mechanical devices and the exceptional minuteness and value of the costs and other statistics derived by this firm, are due to the fact that the statistical methods are tied up with—are a function of—the good management methods.

Graphical Records. Graphical forms of recording statistical data—especially summarizing data—have been found desirable by all well-organized statistical departments. The simple curve is the most useful graphical device. It has properties, not characteristic of tables, which aid the mind in detecting, through the eye, tendencies and relations. There are firms which plot and keep posted daily as many as 1500 or 2000 curves.

The Statistical Department. The statistical function should be performed by specialized clerks trained in the methods and in the manipulation of mechanical devices and in statistical operations. The manager of the department should be above all a man of imagination and of analytical ability. He should suggest, but he alone should not determine what statistics should be kept and what objectives aimed at. Statistics are for use, not for file. The executive and the administrative officers are the users. They should participate in determining what statistics should be kept. Their several desires should be dovetailed into one organic body of statistical records, coördinated by the general manager through the management engineer.

General Information: A Supplementary Function. Statistics is a method of investigation, of securing information. It is logical therefore that other methods of securing information than the statistical should be assumed by the statistical department. Special libraries, including files of books, pamphlets, trade periodicals and newspaper-clippings, of which all the important contents bearing on the business are indexed, are being developed by statistical departments. The department should take the initiative in bringing pertinent information to the attention

[3] Day and Zimmerman, Philadelphia.

of the administrative and executive officers; should establish its information service within the plant.

Conclusion. Statistical results secured in accordance with correct statistical principles and methods—related to operations, posted up to the day, based on homogeneous units—are as important to the well-managed manufacturing plant as are the sextant and the compass to the mariner. They permit the management to know at any moment *where it is* and to set its course. Statistics which yield only records of past events are of no more use than the *log* to the mariner; they do not assist one to shape one's course. Statistics are recorded, classified and analyzed experience. From this experience, so made available, principles may be derived to guide all who are concerned with the determination and execution of policies and with the direction of operations—directors and president, general manager, production and sales managers, employment manager and others according to their respective problems. More accurate forecasting of conditions will be possible and more precise control leading to desired results; more reliable forecasts of demand, more favorable buying, better selection and training of workers and retention of workers; more precise and dependable production methods; and a better schedule of production throughout the year.